THE WELDER

A Monthly Magazine devoted to Electric Arc and Oxy-Acetylene Welding

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Commentary

THE extraordinary development which is occurring in America at the present time in connection with Pipe Line work is truly amazing. The recent financial slump in America is bound to have some delaying action in connection with many of the pipe lines which have been projected. Nevertheless, many of them have progressed so far that they must, at an early date, be completed.

Crude oil was the first material to be conveyed by means of pipe line, but now in some cases actually refined oils are being conveyed by such means. Natural gas is also being piped to a very considerable extent, and water is being conveyed to many of the dry areas in U.S.A. All this development has been made possible by welding processes, and electric arc welding is rapidly displacing other forms of welding which have been used hitherto. Nevertheless, it must be acknowledged that very intricate work has been done by means of the gas blowpipe. Many hundreds of miles of pipe have been welded by means of this method. Not only have the longitudinal seams been welded but the circumferential seams have been welded as well by means of gas. Up to the present the results to be obtained by means of the blowpipe have been in advance of those which could be obtained by means of the electric arc using bare wire for welding. Such welds are notoriously brittle and better results have been obtained with the blowpipe, but America is rapidly being converted to the benefit to be obtained by the use of coated electrodes and it is not too much to say that the electric arc with coated electrodes will displace all other methods at an early date.

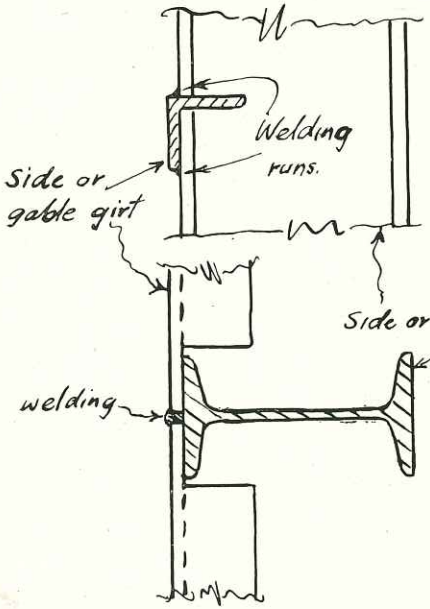
It cannot be expected that pipe line transmission will be used in Europe to the extent it is used in America. In Europe there is no crude oil and no natural gas to pipe, all that we have is coal gas or water. It will certainly be a very good thing for Industry when gas works are located at the Collieries. They are certainly out of place in densely populated towns. The unsightly appearance of the gas holders and the various disagreeable odours, to put the matter politely, makes gas works very undesirable neighbours. It will not take the gas company long to appreciate that it will cost far less to force gas through a pipe that to bring coal by the way of railways or by water transport.

Consequently a fairly early development will occur in gas works being removed from their present location, despite the enormous loss of capital which will temporarily result.

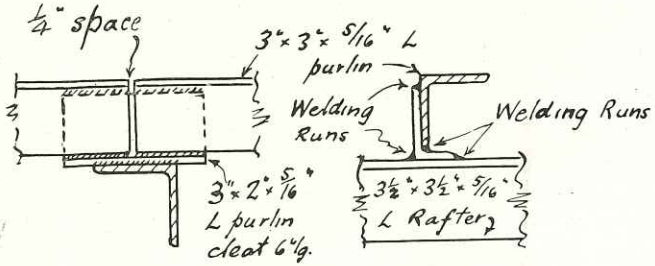
The Design of Welded Steel Structures

by H. A. McCREADIE, C.E.

PART V.

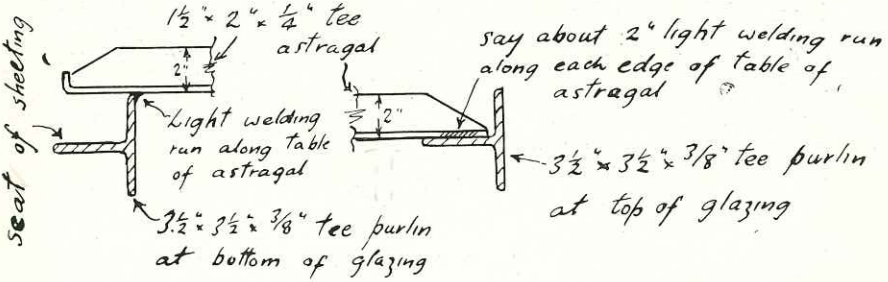


Detail IV.

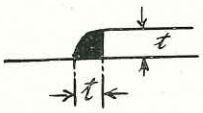


L cleat and welding should be the same at intermediate supports (i.e. where purlin passes over truss rafter without joint.)

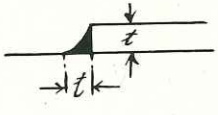
Detail V.



Detail VI



Section of Full Welding Run



Section of Light Welding Run.

t = thickness of plate or bar to be fixed.

Detail VII.

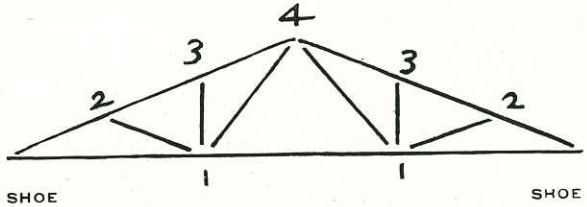
TEMPLATES, GAUGES, ETC.

The interested reader will possibly be asking how these columns and trusses can be accurately fabricated by the welding process, especially as in the structure so far considered holes and service bolts have been eliminated.

Wooden templates (in the case of large quantities and continuous repetition work, steel templates) are made practically on the same principal as for riveted and bolted construction. For example, the template for the 40ft. span roof truss under consideration would mark accurately the positions of web members, and length of welding runs, as well as lengths, slopes and shapes of ends of

bars. Where a large number of similar trusses are to be welded up, (the bars having been cut to size and shape previously) various economical methods will suggest themselves, (in simple work eliminating wooden templates entirely), for accurate fabrication. Stools firmly fixed and levelled on fabricating shop floors or ground adjacent to the site as case may be, could, for large trusses, be placed at panel points, marked, blocked and slotted for the speedy laying down and firm holding of loose bars in position whilst welding is proceeding. With a proper arrangement there will be no need to tack weld the bars in position as a preliminary to the welding proper. Whenever practicable, and where quantities will make it economical, have two welders welding simultaneously in a pre-arranged order.

By welding up the joints of the roof truss herein considered in the sequence indicated on the accompanying diagram, distortion and the ill effects of initial stresses will be almost, if not entirely eliminated. If shoe gussets are used, each shoe in this diagram would be numbered 2, with the remaining joints in the sequence shown. The principle here laid down holds good for any truss having any number of web panels. Gauges (say simple wooden strips cut to exact length and notched), will be used for the accurate spacing of side and gable girts, and of tee astragals and such like in the field.



COMPLETION OF CALCULATIONS FOR BUILDING UNDER CONSIDERATION.

Practically speaking, so far as the calculations are concerned, it only remains for us to consider—

(a) The gable columns.
(b) The gable horizontal wind bracing at Eaves Level.
(c) The side vertical diagonal bracing.
(d) The gable vertical diagonal bracing.

(*a*) *The Gable Columns:*

With no wind on gable the column acts purely as a vertical strut carrying dead loads due to—

(1) Weight of steelwork on gable and roof.
(2) Weight of roof and gable coverings.
(3) Snow load (assumed).

Eccentricity due to any of these loads may be ignored.

The addition of horizontal wind acting directly on (or normal to) gable tends to make the gable column act as a beam supported at ground and eaves level.

The stresses created by these two sets of loadings result in the following, viz. :—

Vertical load from Roof, including Roof covering and snow $= \dfrac{13\frac{1}{3}' \times 7\frac{1}{2}' \times 20\#}{2240}$ tons $= 0.9$

Gable sheeting and girts $= \dfrac{13\frac{1}{3}' \times 24' \times 7\#}{2240} = 1.0$

Wgt. of Column alone say $= 0.25$

$\therefore$ total vertical load (in tons) $= 2.15$

say 20# wind blowing on gable, then total wind (effective) $= \dfrac{20' \times 13\frac{1}{3}' \times 20\#}{2240} = 2.3$ tons

and Bending Moment due to this $= \dfrac{2.3 \times 20 \times 12}{8} = 69$ in. tns.

$\therefore$ Maxm. fibre stress on column (assuming 8″×4″ R.S.J.) $= \dfrac{2.15}{5.29} + \dfrac{69}{13.9}$

$= 5.4$ Tns/□″

This is safe and 8″×4″ R.S.J. will therefore be adopted for gable columns.

(*b*) *Gable Horizontal Wind Bracing at Eaves Level.*

This bracing carries the gable wind to the sides of the building.

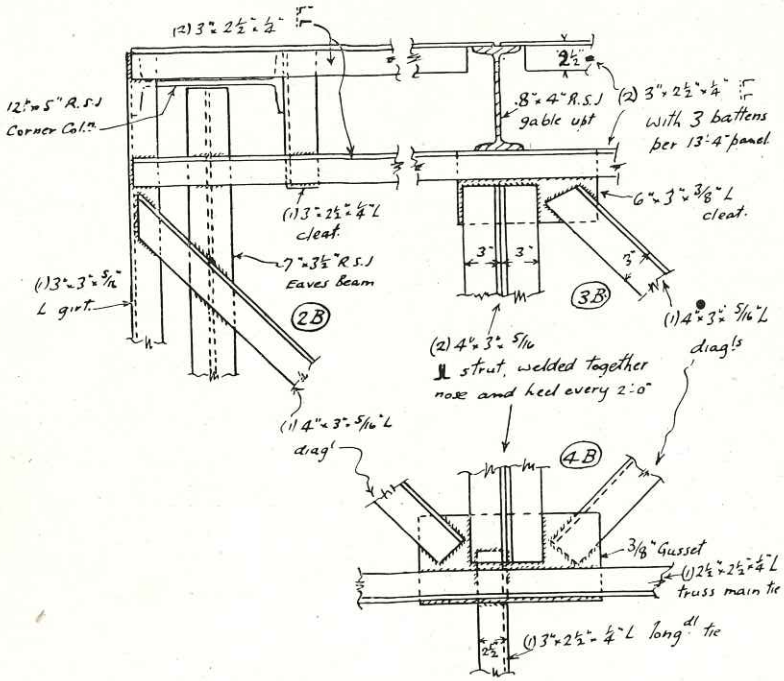
Total wind acting directly on point (3B) (see general drawing) $= \dfrac{13\frac{1}{3}' \times 15' \times 20\#}{2240} = 1.8$ tons

This gives the compression in strut 3B—4B.
assumed section (2) $4'' \times 3'' \times \frac{5}{16}''$ ⌊

$$\frac{l}{r} = \frac{180}{1.26} = 143 \quad fp = \text{say } 2 \text{ Tns/□″}$$

area of 2 Ls $= 4.18$□″

The section is therefore ample when considering the direct compression. It has been chosen owing to the possibility of sag in the length of 15′ 0″.



Plan Details of Gable Horiz.l Wind Bracing at Eaves Level

(Hatch lines have been used to indicate welding)

Considering the diagonal tie 2B — 4B we have—

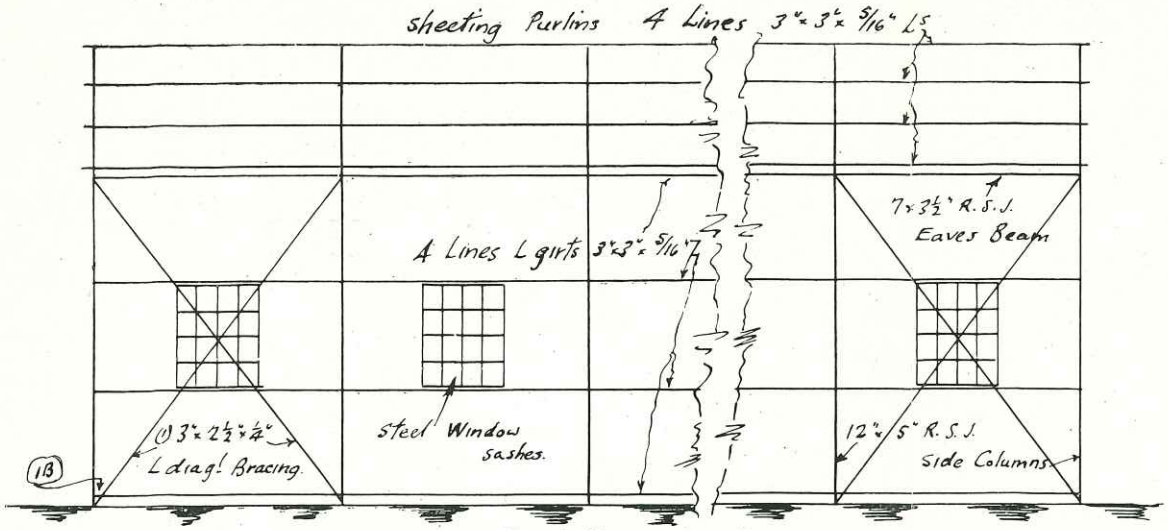
$$\text{tension in the bar} = 1.8 \times \frac{20}{15} = 2.4 \text{ tons}$$

$$\therefore \text{ working stress fw} = \frac{2.4}{2.09} = 1.15 \text{ tns/}\square''$$

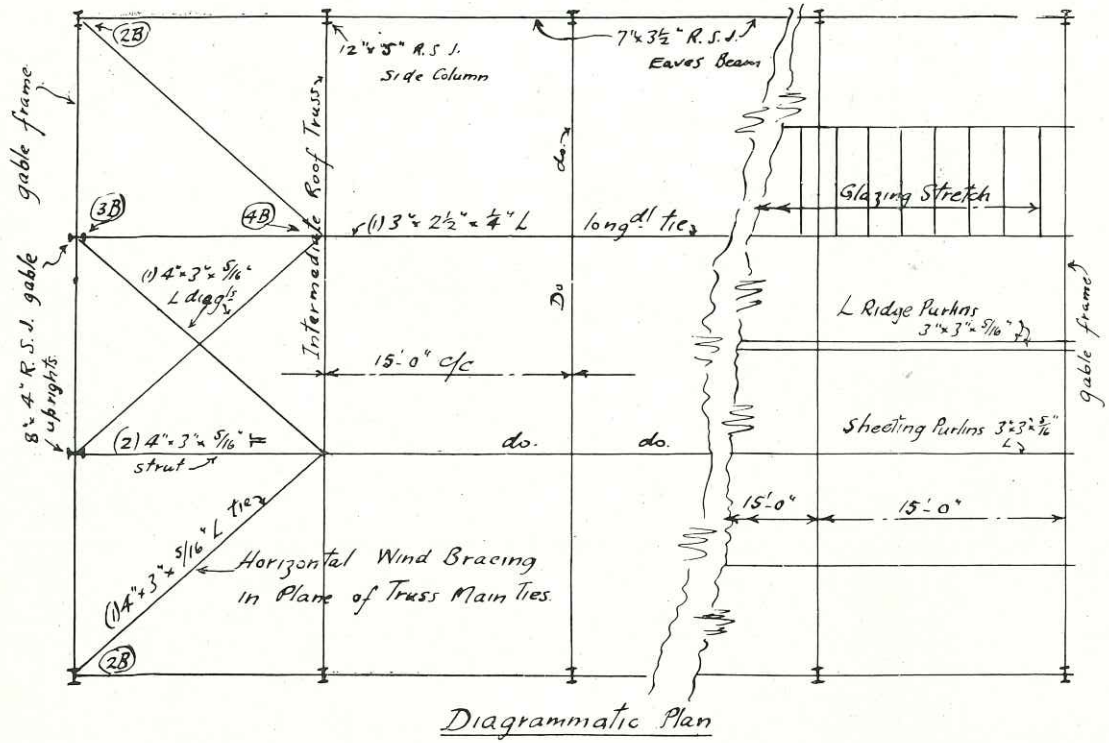
We have provided (1) $4'' \times 3'' \times \frac{5}{16}''$L, with 4″ leg upstanding to counteract sag as far as necessary.

Considering the Horizontal "Boom" of this bracing — member 2B—3B, we have—

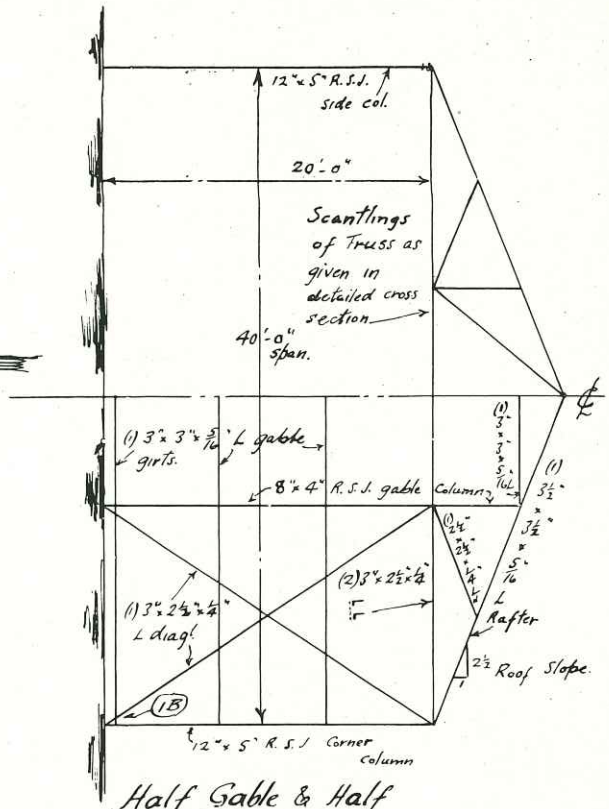
$$\text{stress in member (compression)} = \frac{1.8 \times 13\frac{1}{3}}{15} = 1.6 \text{ tons}$$



Part Side Elevation.



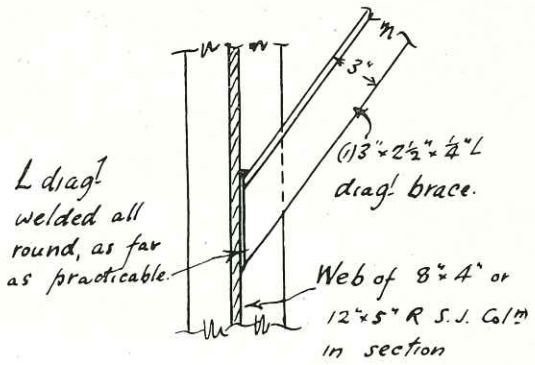
Diagrammatic Plan



Half Gable & Half Intermediate Cross section.

General Drawing of Ordinary All-Welded Steel Framed Building 40'-0" span, × 20'-0" high to eaves, × any length in multiples of 15'-0".

H. A. McGreadie C.E.



Detail (1B)

This member has also to carry gable sheeting and distribute gable wind to panel points; and we have therefore assumed (2) $3'' \times 2\frac{1}{2}'' \times \frac{1}{4}''$ L L battened. The stress in this member is the same in all three panels.

The cross bracing in the central panel has no stress in the system, but is inserted for general rigidity.

The stress of 1.6 tons acts as a tensile stress in the central panel of the first intermediate roof truss. Since this stress obviously does not occur at same time as wind normal to roof slope we need not consider stresses in the truss main tie further.

(*c*) *Side Vertical Diagonal Bracing.*

This carries the wind from the above horizontal wind bracing to ground.

Total horizontal wind acting at point 2B (see general drawing) $= \dfrac{20' \times 15' \times 20\#}{2240} = 2.66\text{Tns.}$

Actual tension in (say) one diagonal $= \dfrac{2.66 \times 25}{15} = 4.45$ tons

Angle provided = (1) $3'' \times 2\frac{1}{2}'' \times \frac{1}{4}''$

$\therefore$ working stress fw $= \dfrac{4.45}{1.3} = 3.4$ Tns/□″

Taking rigidity into account the section should not be less than that given.

(*d*) *Gable Vertical Diagonal Bracing.*

This carries side wind from roof and upper half of side to ground.

Horizontal component of roof wind (by calculation for side columns) $= \frac{0.53}{2} = 0.27$ tons

$$\text{Wind from side} = \frac{10' \times 7\frac{1}{2}' \times 20\#}{2240} = 0.67 \text{ tons}$$

$$\text{Total} = 0.94 \text{ tons}$$

$$\therefore \text{ Tensile stress in (say) one diagl.} = \frac{0.94 \times 24}{13\frac{1}{3}} = 1.7 \text{ tons}$$

(1) $3'' \times 2\frac{1}{2}'' \times \frac{1}{4}''$ L is provided, and therefore, by previous calculation, it is ample.

The horizontal 2B — 3B carries the load 0.94 tons to the diagonal tie, and is obviously sufficient for the purpose.

In the same way, under calculations (c) the eaves beam — $7'' \times 3\frac{1}{2}''$ R.S.J. carries the load 2.66 tons to the diagonal tie, and is sufficient for the work.

The additional diagonal angle shown in each case on general drawing is for rigidity.

There would appear to be no need to give calculations for the length of welding runs as these can be made readily by the reader who desires to do so, from a perusual of Part III.

GENERAL SUMMING UP.

An examination of the drawings given in Parts II. and III. will show that we have eliminated the web gussets which are a common feature of all riveted and bolted roof trusses.

The saving in weight due to this alone might amount to 60 lbs. per truss—a substantial item when large quantities are considered.

The general drawing shows, in diagrammatic form, the design and general layout of the building we have been considering.

This type of structure is economical and adaptable for many purposes, which makes it of interest to almost all parties scheduled in Part I.

Next month we hope to give consideration to another type of structure which can give as perfect service, as a welded unit.

(To be continued).

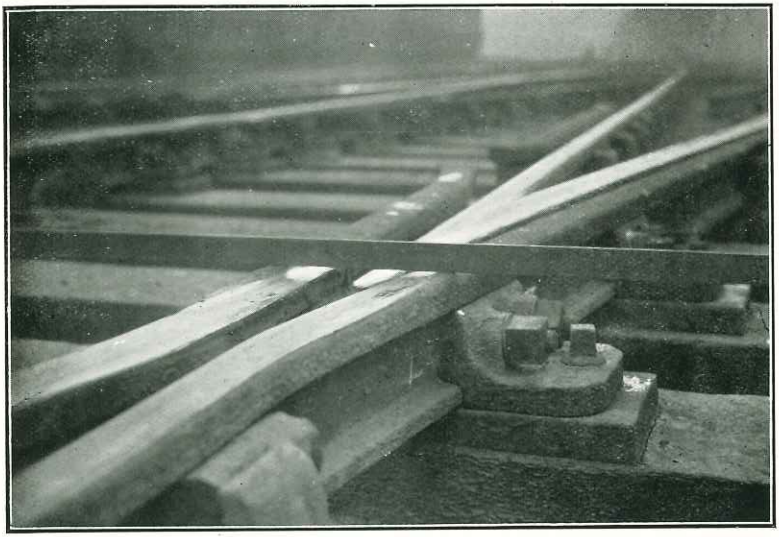


Fig. 1.—Worn Railway Crossings.

Worn Railway Crossings

RENOVATION BY ELECTRIC ARC WELDING.

THE following description of the latest developments in this direction will be of interest to railway engineers especially as at the present time railways generally are obliged to effect all possible economies.

It is well known that crossings built up from rails of ordinary composition say .45—60% Carbon Steel have a very short life under severe traffic conditions and many crossings are removed from the track owing to serious local wear at the nose of the point rail (the vee) and on the wing rails at the throat or knuckle, in spite of the fact that the other portions of the crossing rails are in a perfectly sound and serviceable condition. It is well known that under electric stock the wear of crossings is more rapid than when steam locomotives are used.

The application of electric arc welding on railways in connection with the renovation of worn crossings has made comparatively slow progress, probably due to the fact that hitherto the deposited metal

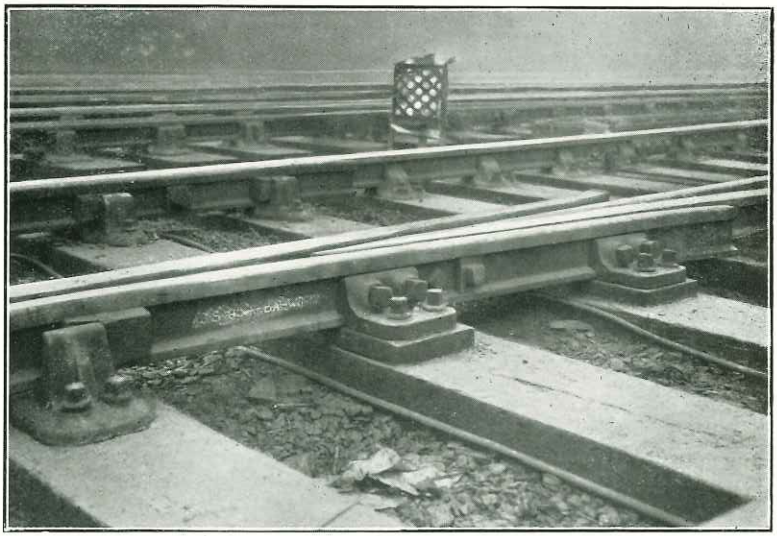


Fig. 2.—Railway Crossing Welded up.

has lacked perfect adhesion, mechanical strength and resistance to wear, but Murex Welding Processes Limited are now in a position to supply an electrode which makes this class of work a practical and economical proposition.

At Cannon Street, one of the Southern Railway's large London terminal stations several crossings have been re-conditioned with most satisfactory results, using the latest M.W.P. Electrodes "Rolex."

A photograph (Fig. 1) shows a crossing badly worn to a depth of $\frac{3}{4}$-in. and Fig. 2 shows the crossing as it appears after having been welded and ground.

The welding outfit consisted of a Standard A.W.P. portable set comprising a Morris Petrol Motor of 12 h.p. (4 cylinder), running at 1,500 revs. direct coupled to a D.C. Welding Dynamo, rated at 200 amps. and 30 volts (70 to 80 volts on open circuit), of the well-known A.W.P. type with drooping characteristic, i.e., as soon as the arc is struck the open circuit voltage drops to 25—30 volts.

For the light runs No. 8 electrodes were used (140—150 amps), while for the heavy runs No. 6 electrodes were used (165—175 amps.) It is estimated that a badly worn crossing requires about 100ft. of electrodes, 1/3 being No. 8, and 2/3 being No. 6.

The actual welding of one crossing occupied about 4—5 hours (including interruptions due to traffic) while the grinding

took a further 4 hours. A small 1¼ H.P. Motor (D.C. at 50 volts) drives a grinding wheel 8-ins. diameter by 1¼-ins. at about 3,000 revs. through a flexible shaft. The point of the nose of the crossing is about .20 ins. below the running face of the wing rails and gauges are provided for the guidance of the grinder to ensure correct profile of nose and wings and flangeway clearance.

The work was done during day time and without interfering with traffic in any way.

It is estimated that the cost of renovating a crossing is about £4 to £4 10s., or approximately one-third the cost of providing and fixing a new vee and wing rails.

Welding for the Steel Foundry

ON Wednesday, 11th February 1931, Mr. V. Gordon Pearson of Edgar Allen & Co., Ltd., Sheffield, read a very interesting paper entitled "Steel Foundry Welding" before the Institution of Engineering Inspection at the rooms of the Royal Society of Arts, John Street, Adelphi, London.

Mr. Gordon Pearson, it should be noted, has had perhaps more experience in welding as concerns the Foundry Industry, than perhaps any other Engineer in this country, and his paper marks a step forward in the development of Arc Welding.

The Lecture was followed by a general discussion. We regret that owing to lack of space we are unable to publish a full account of both the paper and the discussion, but these can be obtained on application to the Institution of Engineering Inspection Incorporated, Palace Chambers, Westminster, London, S.W.1.

THE WELDER BINDER

Arrangements are now being made to provide covers for Volume II and these will be supplied at a charge of 9d. to include postage and packing.

These Binders are stronger than those issued for Volume I, being bound in American cloth.

Each Binder will hold twelve issues of "The Welder."

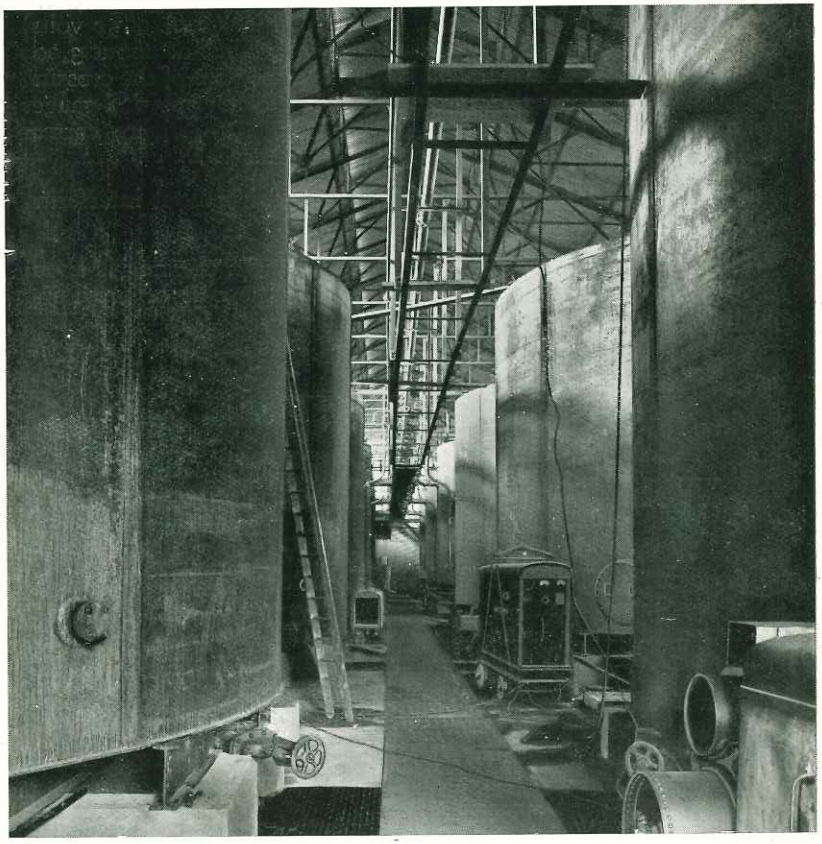


Fig. 1.—Welded Tanks in Position.

Welded Tanks for a Distillery

LIKE other new processes, electric welding was not accepted in the engineering world without passing through a probationary period in an atmosphere of doubt and suspicion. While manufacturers have always appreciated the advantages of the system for certain classes of work, it was felt in many quarters when the construction of vessels subjected to pressure and other similar work requiring an ample margin of safety came under consideration that in dispensing with bolts and rivets too much was being left to chance. That some of the misgivings in the early days were justified is undoubtedly true, for unsuitable plant and electrodes and inexperienced operators made electric welding much less satisfactory than at the present time. Since those early

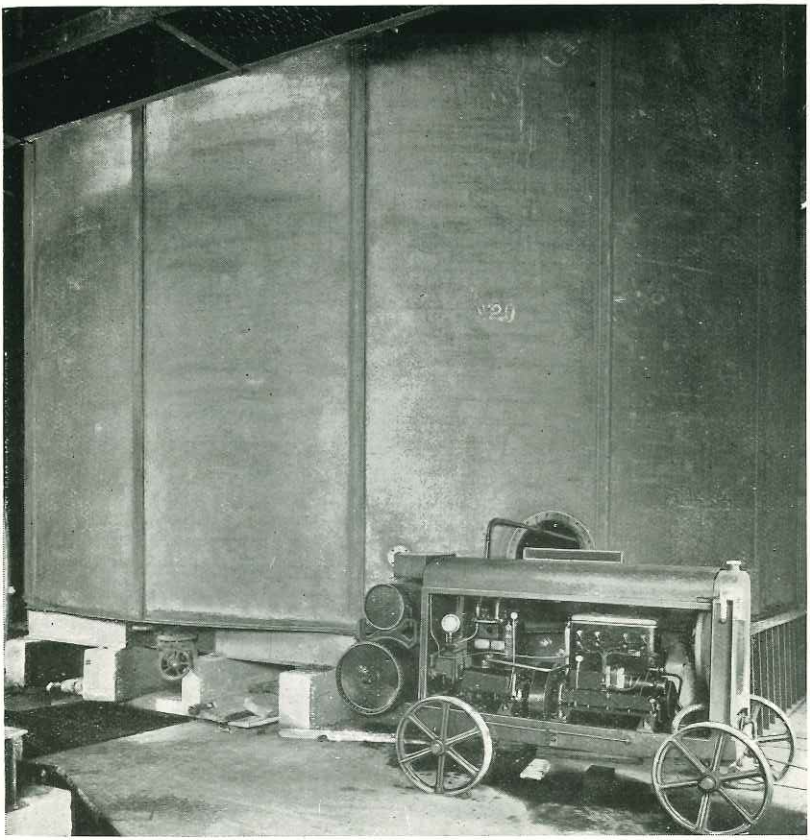


Fig. 2.—Near View showing Joints.

times a large amount of experimental work has been carried out and much experience has been gained, with the result that the system is now widely used for jobs on which strength is a matter of vital importance.

With the permission of John Thompson (Dudley) Ltd., we show in Figures 1 and 2 a group of tanks erected by it at a large distillery in the North of England, and on which the circumferential plating is a departure from standard practice. The plates are continuous throughout from the bottom to the top, a vee butt weld being employed on the inside—see Fig. 3— and a welded butt strap on the outside, as shown in Fig. 2. A view of the tops of the tanks is given in Fig. 4. The construction, the makers point out, not only ensures a joint having a strength greater than the plate itself, but it also improves the appearance of the structure.

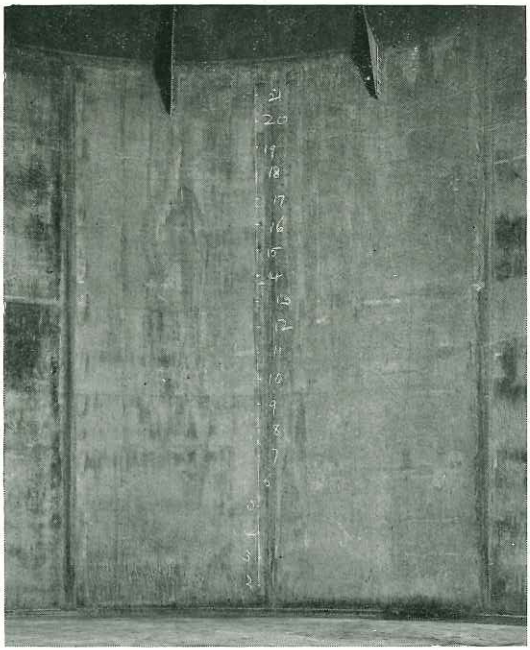


Fig. 3.—Interior View showing Smooth Joints.

The plates were, of course, cut, rolled and prepared in John Thompson's works, but the whole of the erection was done on site without the use of bolts and rivets. The tanks are used for the purpose of conserving large quantities of hot fermenting liquor which gives off a heavy gas at certain temperatures and which behaves in a peculiar way. If kept in circulation its action on a plain surface of steel is negligible, but if permitted to remain in the same place for any length of time it has a corrosive effect.

Experience has shown that if the liquor is stored in an ordinary riveted vessel rapid deterioration of the vessel takes place, owing to the tendency of the gas to lodge under projections, such as bonding edges and rivet heads, gussets, etc., where it gives rise to deterioration of the metal.

These undesirable conditions clearly indicate the advantages of a tank with a flush interior free from projections of any kind, and that was the problem presented to John Thompson (Dudley)

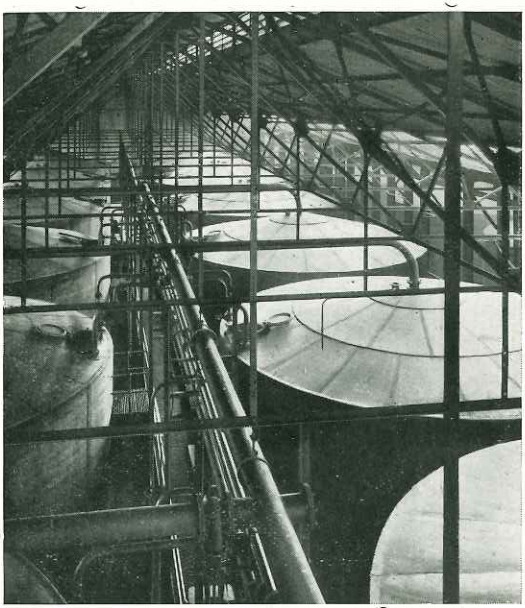


Fig. 4.—View along tops of Tanks.

Ltd., when it was awarded the order for twelve tanks for the distillery, each 30ft. in diameter and 25ft. high. The firm's technical department proceeded to produce a design that complied with these unusual requirements, and in due course the tanks were delivered and erected on site. As the major part of the welding had to be done on a vertical surface and a good porportion overhead it may appear that difficulties and disadvantages were met with, but we are told that by the use of "Premier general service" electrodes no trouble was experienced, and all the tanks passed their test entirely satisfactory. The sequence of welding when operating on work of this kind is a matter of great importance, and care must be taken not to permit the contractional stresses subsequent upon welding to accumulate, otherwise the ultimate stress at various parts of the structure may reach the danger limit, to say nothing of the distortion that must ensue. Electric welding, the makers of these tanks point out, provides the strongest and most rigid form of construction, but it is futile to regard it as a foolproof operation, requiring no knowledge or experience.

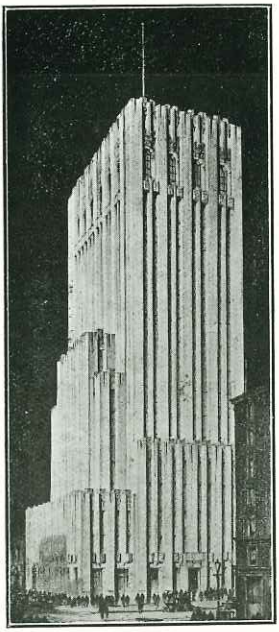


Fig. 1.—Office building with steel frame, fabricated and erected by Electric Arc Welding.

The Tallest Welded Building

By ORVILLE ADAMS.

THE Dallas Power and Light Company's office building built in 1930 was the world's largest welded structure up to that time. It is located in the down town district, the most congested section of the city of Dallas, Texas, adjacent to large hotels, banks and apartments. Noise on this building during construction would have been very objectionable, and for this reason it was decided to weld the steel work instead of riveting. Electric hoist instead of steam donkey engines was used in erection work.

The nineteen story portion of the building is 100ft. x 100ft., up to the fourth floor, 77ft. — 4ins. x 100ft. — 0ins. to the sixth, 77ft. — 4ins. x 96ft. — 6ins. to the twelfth, and 54ft. x 96ft. — 6ins. above. There are additional set-backs at the four corners. The foundations are on rock, the column loads being distributed by means of rolled slabs, with no grillage employed.

The steel work is composed of rolled columns, some with

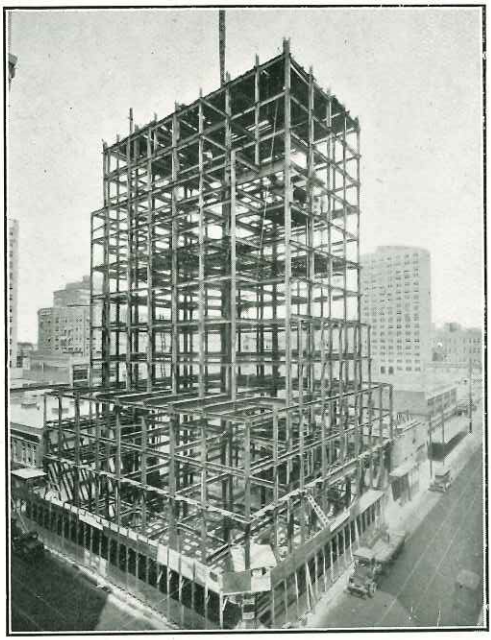


Fig. 2.—The tallest welded building under construction.

cover plates, three built up plate girders, nine roof trusses and beams. The floor system is long span requiring only beams from column to column, except in the rear bay around the elevators and stairs. The eighteenth storey is an open room two stories high with a balcony or mezzaine floor across the rear. The nineteenth floor and roof are carried on trusses spanning the full width of the building.

The architectural features of the building required the design of the steel work to be somewhat out of the ordinary, making the details more complicated than usually found in a building of this class. However, unusual details were more easily made by welding than could have been made by riveting. The steel frame is adequately braced for wind loads.

All the shop work, except three plate girders, was welded. Holes were punched or drilled in the members for erection purposes only. The members and details were prepared in the same manner as for a riveted job up to the point of assembling. A few clamps were used in assembling the individual pieces, but must of the details were held in place by hand and tack welded sufficiently for handling. The assembled members were then moved to the

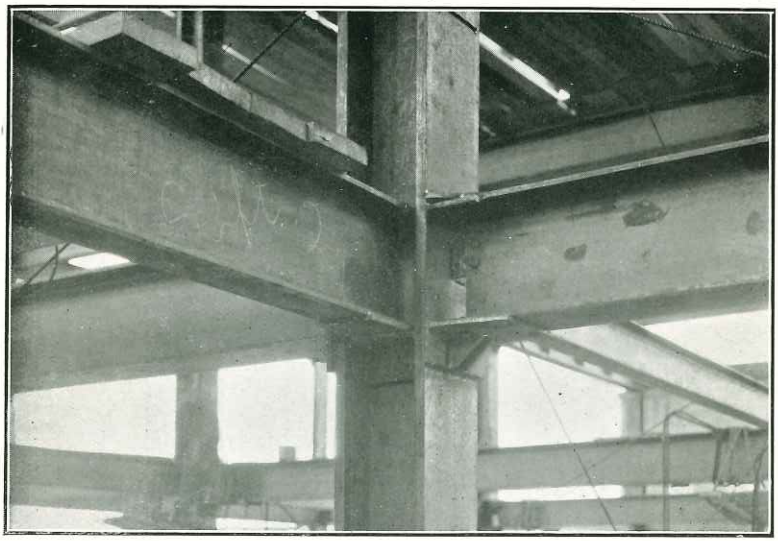


Fig. 3.—View of Girder connections.

welding skids for final welding. The assembled members were rolled or turned for the welders so as to do down welding in nearly every case.

The steel frame was erected at the rate of four floors per week, in the usual manner, the same as a riveted job. A mast derrick with an eighty-foot boom was used. The welders followed the raising gang, keeping within six floors of the derrick. The details were designed so that no overhead welding was required in the field.

The details were made with the idea of doing all field welding without the use of scaffolding. This idea was not carried out. The field work was done in the hottest month of a very hot season and it was asking too much of a man to lie on a hot beam, with his back exposed to the sun, his face to the welding arc and then weld the bottom flange of a beam. Light scaffolds were provided which were moved ahead of the welders by the erecting crew.

The shop and field welding was done with 200 ampere, motor driven machines. There were five welders on the field work, each man having a machine. The machines were placed on the first floor, then raised to the ninth floor where they remained until the finish of the work. Beads, shop and field were $\frac{1}{2}$in. and 1in. The welding wire was $\frac{5}{32}$in. and $\frac{3}{16}$in. Before being allowed to work on the job all welders were given qualification tests. The welding was thoroughly inspected.

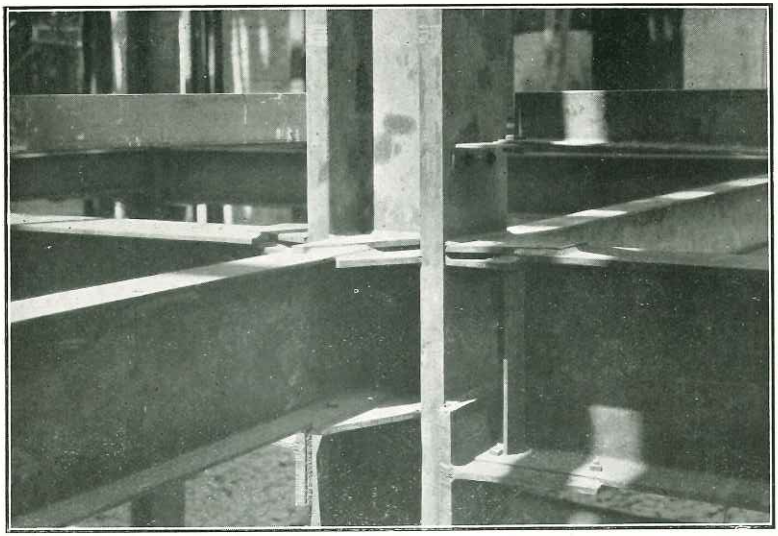
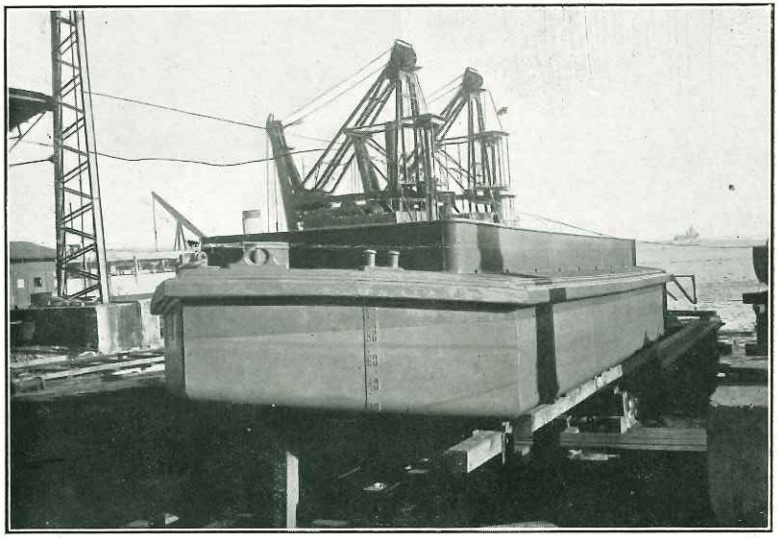


Fig. 4.—Another view of Girder connections.

The frame work of this building was erected and welded with no more noise or commotion than the ordinary trucking on the streets. The welding, did however, attract considerable attention from the public.

In the illustrations are shown wind bracing connections of beams to an interior column. The connection on the flange of the column is made as follows : The seat is a part of a beam, with stiffener on the lower side, all shop welded to the column ; the beam flange is welded to the seat in the field. The side lug, for erection purposes only, is shop welded to the column, and not welded to the beam at all. The plate on the underside of the top flange of the beam, slotted to clear the web is shop welded to the beam and field welded to the column. The top plate is field welded to column and beam. The top plate was required to get enough weld to the column without doing overhead welding as planned. Column splices are shown in the cut.

Lang and Witchell, Dallas, Texas, were the architects, The steel work was designed by Mr. R. L. Rolfe, of Gardner and Howe, Consulting Engineers. The welding was done under the supervision of Mr. Frank P. McKibben, Black Gap, Pa., and Carson and Carson, Consulting Engineers of Philadelphia, Pa. The steel work was fabricated and erected by Mosher Steel and Machinery Co., Dallas, Texas. Mr. R. R. Luttrick is Chief Engineer and Mr. J. P. Churchill, Works Manager.



Welded Barge at Spezia, Italy.

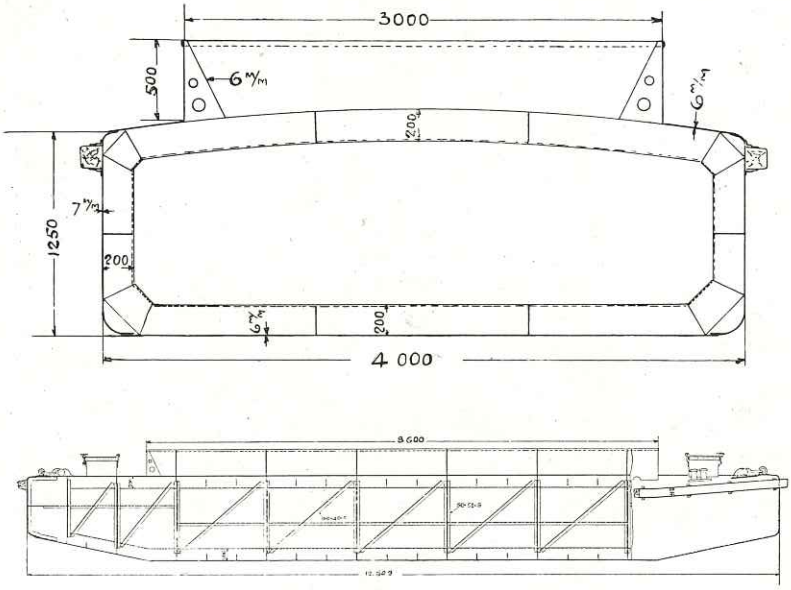
All Welded Steel Barge

THIS Barge was constructed by the Italian Naval Authorities in the Dockyard at Spezia and was specially designed with a view to obtaining as much information as possible concerning the application of welding to ship structures. In order to obtain the maximum strength with the minimum of weight, the frames and the fore and aft stiffeners were constructed from special "L" shaped beams rolled for the purpose. By attaching these beams direct to the hull plating, angle bars were completely eliminated, and the required stiffness and strength obtained with the minimum of steel.

The Barge which is shown in longitudinal and midships section in figures 1 and 2 is 12.5 metres long and 4 metres in breadth. The shell plate is 6 m/m in thickness on the bottom and deck of the vessel, and 7 m/m thick on the sides.

As will be seen from the photograph of the completed vessel, there are no longitudinal seams in the hull, the sides being each constructed of two plates the full depth of the vessel ; these plates being bent to form the turn of the bilge.

As the vessel is constructed to carry ashes, it is provided with a large hatch extending practically to its full length. The hatch



coaming is constructed of four millimetre plate stiffened along the upper edge by the attachment of a half round bar.

A wooden rubbing strip extending round the whole of the vessel is attached to the hull by means of angles welded to the shell plating. All the deck fittings, except the bollards, were constructed by welding and were welded in place.

The completed Barge has now been in service for several months and is, we understand, giving every satisfaction.

The work was carried out by Dockyard welders using Belfinish Electrodes throughout.

"THE WELDER" PRIZE COMPETITION

The Proprietors of "The Welder" offer a monthly prize of £5 5s. for the best illustrated article describing interesting jobs undertaken by the Electric Arc Welding Process. Full particulars relating to this Competition can be had on application to "The Welder" Ferry Lane Works, Forest Road, E.17.

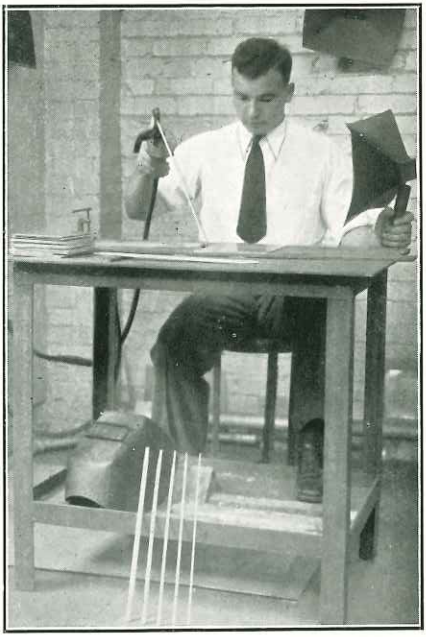


Fig. 1.—The proper angle at which to hold Electrode.

The Electric Arc Welding of Aluminium

By W. M. DUNLAP.

FUSION welding has been divided into two general classes: Torch welding and arc welding. The fusion welding of aluminium and its alloys by means of an oxy-hydrogen or oxy-acetylene torch is an art that has been known and practiced for the past fifteen or twenty years by metal workers engaged in the fabrication of aluminium articles. During the past year there has been much information concerning the torch and spot welding of aluminium and its alloys published in the various technical journals. However, there has been nothing published concerning the arc welding of the above metals. The concensus of opinion seems to be that aluminium cannot be arc welded. This opinion was entirely correct until a short time ago. During recent months rather extensive investigations of the applications of the electric arc welding process to aluminium have been made. As a result of this work the process has been developed to the point where, within certain limits, it may be considered practical as a production method.

The arc welding process is divided into two general classes: Metallic arc, or Slavianoff process and carbon arc, or Bernardoes

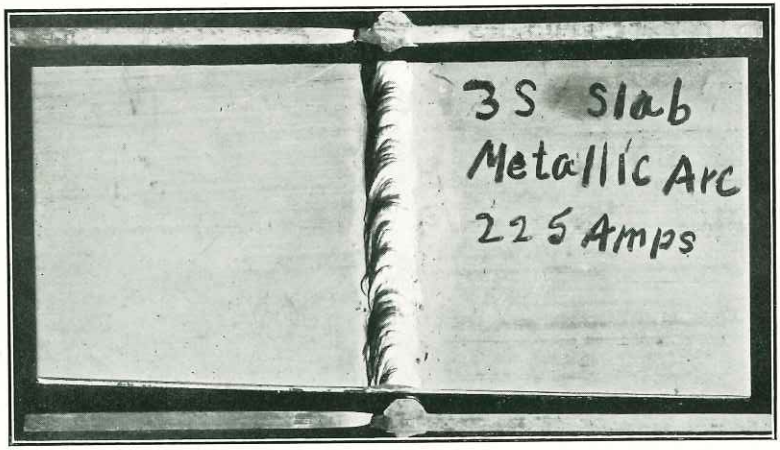


Fig. 2.—Metallic Arc Weld in 7/32″ Aluminium plate. Test Coupons shown at top and bottom of picture had a tensile strength of 17,000 lbs. per square inch and an elongation of 15% in 2 inches.

process. Both of these methods are now being used for welding aluminium, however, the former process only will be discussed in this paper.

Electric arc welding dates back to about 1881 and the general principles of the process are well known. This paper will discuss the application of these principles to the welding of aluminium.

The first principle involved is the heating of the work to a welding temperature by means of an electric arc produced or "struck" between the work and a metallic electrode. The electrode melts and feeds into the joint, thus supplying the material required to complete the weld. The arc serves three distinct purposes :— It supplies heat to melt the edges of the joint, heat to melt the electrode metal, and it carries the metal from the electrode to the weld. The electrode serves two purposes : It constitutes a portion of the electrical circuit, and is a source of filler metal for the weld.

A welding generator having a current rating of from 50 to 300 amperes will be found satisfactory for most aluminium welding. A variable voltage machine having an "open circuit" voltage of 60 volts and an operating voltage of about 20 to 30 volts is quite satisfactory. The machine should hold a stable arc at low currents, but trouble from this source can be corrected by placing a 1 to $\frac{1}{2}$ ohm resistance in series with the arc.

The electrodes used are of the flux-coated type. In fact, the whole secret of successfully arc welding aluminium and its alloys depends upon the use of a proper flux. The diameter of the wire will vary with the thickness of the material to be welded. A $\frac{1}{8}$-in. diameter electrode will prove satisfactory for material from $\frac{1}{16}$-in.

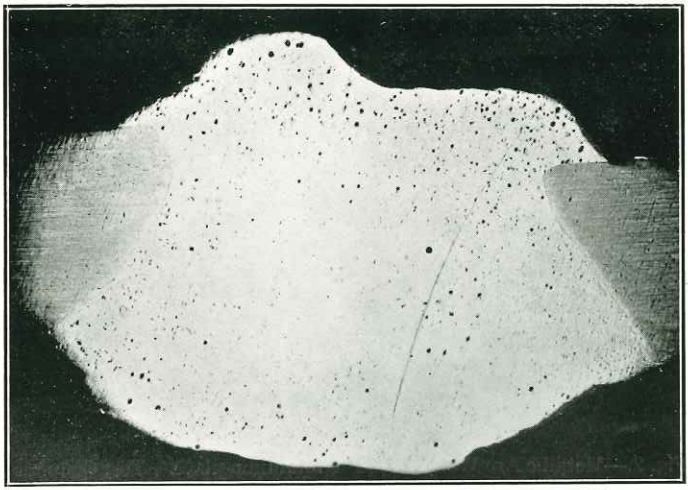


Fig. 3.—Mag. 5X Unetched Cross Section of Weld shown in Fig. 2.

to $\frac{3}{16}$-in. thick, and a $\frac{3}{16}$-in. electrode is suitable for welding material from $\frac{3}{16}$-in. to $\frac{5}{16}$-in. thick. The diameter of the wire should be approximately equal to the thickness of the sheet. Since the flux coating is an insulator, it is necessary to limit the electrode length to such that when it is gripped at one end by the electrode holder, it will not be unwieldy. Experience has shown that an electrode about 15-ins. long and coated to within one inch of one end is quite satisfactory.

The torch welding of aluminium was never a real success until a suitable and satisfactory flux was developed. Now that the flux method of welding this metal has become standard practice with the artificers, the torch welding of aluminium has reached a state of perfection. Just as a proper flux is essential for torch welding, so it is for arc welding. Early experimental work quickly showed that a bare electrode would not prove satisfactory for arc welding aluminium, so investigations were begun to develop a satisfactory flux. Such a flux must serve the same purpose in arc welding that it does in torch welding. In addition, it must decrease the surface tension of the aluminium so that the molten metal will flow smoothly from the end of the electrode without the formation of drops; the flux should also aid in stabilizing the arc.

The metallic arc is almost inherently unstable for several reasons. One reason is that the filler metal must pass through the arc during the welding operation. Then, too, the normal tendency of the arc is to "pull off" a cold spot in preference to a hot one, and this leads to an unstable condition.

The flux coating on the rod is the primary stabilizing agent of

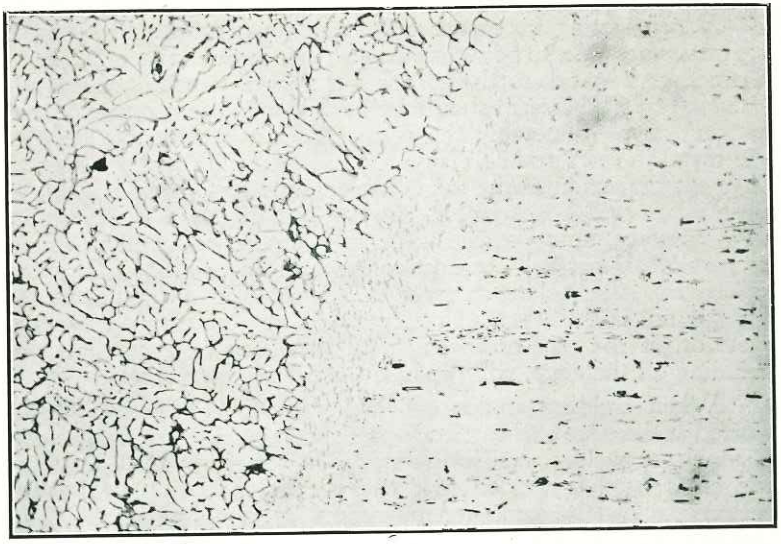


Fig. 4.—Mag. 100X. Etch 1/2% HF. This photomicrograph shows the transition zone of weld shown in Fig. 4. The cast structure of the weld proper is shown on the left, the transition zone in centre, and wrought structure of base metal on right.

the process. The flux, in this capacity, must serve three important functions. It should provide an insulating sheath around the arc, produce arc vapor with good conductivity, and reduce the surface tension of the molten electrode metal so that it will pass through the arc in small globules rather than in large drops. A further aid in stabilizing the arc is the use of a short arc-length.

In welding aluminium with the metallic arc, only one polarity is required, regardless of the alloy being welded or the thickness of the stock. This polarity is with the electrode positive and the work negative, or what is commonly called "reversed polarity."

Preparation of the edges is not required on sheet up to $\frac{1}{8}$-in. in thickness, as the metallic arc will produce complete penetration when the edges are merely butted together. Material thicker than $\frac{1}{8}$-in. however, should have the edges bevelled to form a 90 degree vee. This vee should not extend completely through the plate, but about an $\frac{1}{8}$-in. lip should remain. Heavy areas of irregular sections, such as points where web and flanges intersect or at the corners of an angle in extruded or rolled shapes, should be veed out to secure complete penetration. The face of the vee should be about $\frac{1}{4}$-in. wide at its maximum, while the root should be carried to within $\frac{1}{8}$-in. of the reverse side of the section. Corners can be prepared by filing or grinding at any angle of about 45 degrees with the plane of the joint.

When setting up material for welding a jig should be used, whenever possible, to hold the various parts in their proper position. Clamping the work to the top of a table will usually prove quite satisfactory. The seam should be backed up with a copper or iron backing strip—preferably the former. This is advisable because the metal in the "puddle" is quite fluid, and, unless some support is given, the action of the arc will blow holes through the weld, or penetration will be excessive. If the backing strip is flat on its entire surface, however, the under side of the weld will be found to be slightly concave, due to contraction on cooling. To avoid this trouble, the backing strip should be made with a slight clearance directly under the seam. Cutting a shallow groove in the backing plate or, in the case of an angle used to back up a corner weld, grinding off the edge, will produce the desired clearance.

When welding angles or channel sections, the welding is started at the edge and carried towards the angle. The flanges of a channel are welded before the web. When joining tee-sections, the cross head is welded first and the leg next. H or I-beam sections follow the same general procedure, flanges first and then web. Mitre welds are usually started at the point and welding carried towards the angle. In all cases where the thickness of a section being welded varies, the welding should start at the thin point and progress towards the heavier section.

Movement along the seam may be in either a forward or backward direction, as the operator desires or as the work dictates. The movement, however, should be at a uniform rate so that an even bead is made. The arc should always be kept as short as possible. An arc length of about $\frac{1}{8}$-in. is the most satisfactory, and it should never exceed $\frac{3}{16}$-in. When a long arc is used, the arc "waves" excessively, small globules of semi-molten metal are thrown about, and the arc is hard to maintain.

After a little practice, the operator will find that the arc welding of aluminium is a very simple process. There is no weaving of the electrode as in steel welding. The electrode is advanced in a straight line along the seam. In the case of heavy plate, the electrode is moved forward and backward to build up a bead of the desired height ; the electrode is never moved back and forth across the weld.

The flux used in arc welding, like that for torch welding, is corrosive and must be removed after welding is completed. The most satisfactory method for removing the flux is to soak the weld in hot 5% sulphuric acid solution for a short time and then to rinse it in hot water. Soaking in hot water, at the same time scrubbing with a stiff brush, is also quite satisfactory. The weld may be cleaned by impinging a steam jet on it. This method has advantages for removing flux from corners.

The metallic arc can be used for welding aluminium sheet

#14 B. & S. gauge and heavier. An upper limit has not been set, as this limit depends more upon the results desired than on the possibilities of the process. The heaviest material used experimentally was $\frac{3}{8}$-in. plate, and the welds were very satisfactory.

The lower limit can rather definitely be placed at #14 gauge as it has been found that lighter material will burn through with the aluminium current that can be used. This trouble appears to be an inherent characteristic of the metallic arc. It is chiefly due to the fact that the minimum current which will maintain a stable arc generates too much heat for light sheet.

Most metallic arc welds in light material are slightly porous. This is probably due to the extremely rapid rate of fusion and resolidification, which has a tendency to entrap gas as the metal freezes. This condition can be minimized by using as high a current as it is possible to use without burning holes in the work. The high current makes the weld more fluid and permits the gas to escape more completely. The porosity has little effect on the weld strength, but may interfere with the finishing operation, as, in grinding off the excess weld metal, the small pores may be exposed. Peaning the weld will usually close these pores. Another common practice for welds which must be finished, is to weld from the reverse side and grind off the "penetration bead."

The most outstanding advantage in the use of metallic arc welding is its cheapness; the operating speed of this method is greater than for any other fusion welding process. Where applicable the arc welding process is cheaper than the oxy-hydrogen or oxy-acetylene welding process. This saving is in the difference in the cost of gas as compared with the cost of electrical power, and in the difference in labor cost. The first cost of the arc welding process will probably be greater, especially for small installations, while the cost of the electrodes will be somewhat more than for filler wire and flux in torch welding. The decreased operating costs, however, will soon show a saving.

Murex Welding Processes Limited, list electrodes for welding aluminium, which are manufactured in accordance with their patents. These electrodes are prepared with a well-designed flux coating so that they are ready for use. Excellent welds can be made with them under favourable conditions. It must, however, be understood that the production of good electrodes does not eliminate the many difficulties which are to be expected in the welding of aluminium parts.

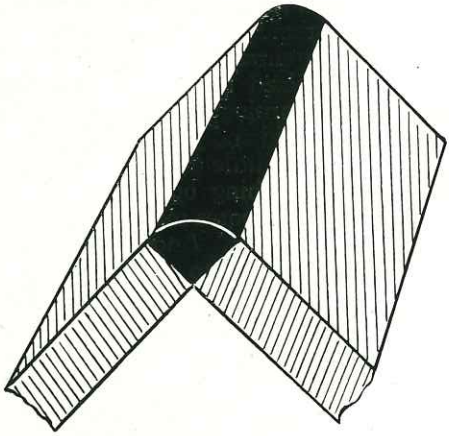
Mr. W. M. Dunlap gives a description of the procedure which should be adopted in the welding of aluminium. We should, however, like to add that it is essential that the job must be preheated before attempting to carry out any welding.

We shall be pleased to give any further information that might be required on this subject.

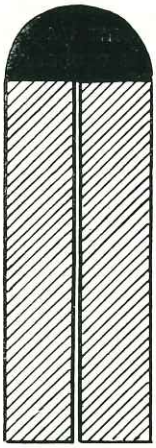
The Welding of Mild Steel with Cresta Electrodes for Forging Purposes

By WILLIAM BENNETT

THE following facts relating to tests carried out with Cresta Electrodes by a north-country foreman welder should be of general interest to all, and were quite unsolicited by this Company.

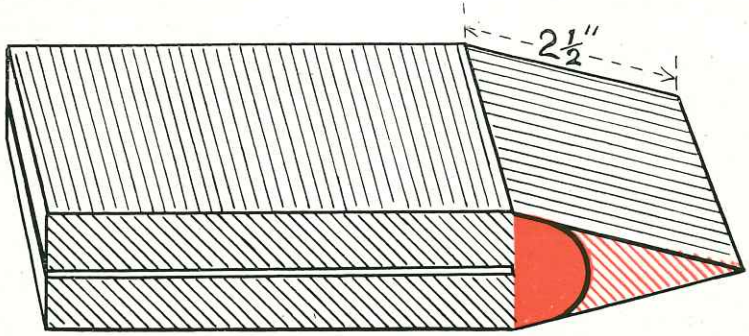


Weld completed ready for testing.



Weld sound after bending.

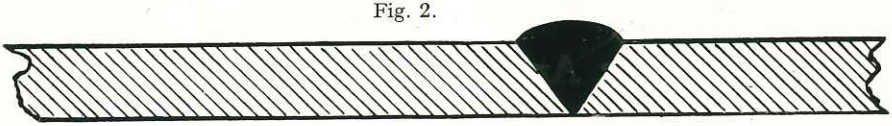
Showing the Welded -Metal drawn out to a Feather Edge. Length of same.



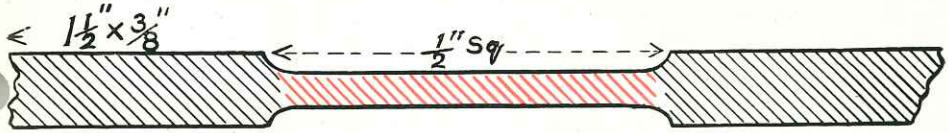
TEST PIECE AFTER FORGING. No sign of any fracture whatever.

Fig. 1 shows two pieces of Mild Steel Boiler Plate, 4ins. x 2½ins. x ⅜in., 25-27 Tons Tensile welded together at an angle of 90°, thus forming its own "V." The first run was made with No. 10 S.W.G. Cresta Electrode, the second run to fill up the "V" being made with a No. 8 S.W.G., and an inside run to complete the

Fig. 2.



$1\frac{1}{2} \times \frac{3}{8}$ MS PLATE. Welded ready for forging.



MS bar drawn down ready for Bending Test
No sign of any fracture.

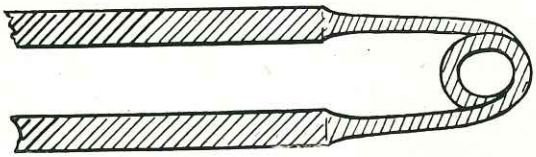


Fig. 3.—Bent and Twisted. No sign of fracture.

Test Piece with a No. 10 S.W.G. After welding, the test piece was taken to the vice and closed up cold, and then for easy handling, while forging, a piece of $\frac{5}{8}$in. round Bar was welded to one end. This was then heated up to a bright red heat, and forged out to a Feather Edge. To my great surprise not a single sign of a fracture showed, and I must point out that only the Welded Metal in this case was being forged, and same was given no "quarter" but most severely punished, and so speaks volumes for the quality of Cresta Electrodes.

A second test was then made with a piece of Mild Steel Bar, 16ins x 2ins. x $\frac{3}{8}$in. Welded to this is another piece of 6ins x 2ins. x $\frac{3}{8}$in. These pieces were prepared in the usual way, and welded together with "Cresta" Electrodes, sizes 12 and 10 S.W.G. being used. The Test Piece was then taken and heated up to a bright red, and forged down to $\frac{1}{2}$in. square and was then taken to the vice and twisted and bent as per sketch, no sign of any fractures showing.

Having had over 25 years' experience in Welding and during that time tested all the well-known makes of Electrodes, I have not met with any that can compete with the Cresta for easy manipulation, low amperage, easy slagging, after welding, and finally a first-class finish on one's work when completed.

Since making the above mentioned tests may I mention that scores of welds have been made and are still being made on plates of $\frac{3}{4}$in, $\frac{7}{16}$in. $\frac{9}{16}$in. and upwards and flanged afterwards, in my department ,which is claimed to be one of the largest welding shops in the North of England, and up to the moment of writing, not to my knowledge, have we yet had a single fracture. This I think speaks far louder than words for the quality of the "Cresta" Electrode as a Hot Forging Electrode.

Electric Arc Welding on Ships

By J.M.L.

ELECTRIC Arc Welding in Ship Construction is not so extensively used in Great Britain as in America or on the Continent. The cause of this condition is obviously due to the conservatism of the Shipbuilder and Shipowner, who, in spite of the data and particulars published from time to time in the Engineering Journals, refuse to discard the riveted connection. This attitude, although not encouraged by the various Classification Societies, is not exactly discouraged by them, and, until the latter give welding their whole-hearted support, then progress in this direction is sure to be slow. There are, however, a few minor and non-structural items, on which these Societies will permit welding to be employed. other items of structural consequence may also be welded, but these are, in the case of British Corporation and Lloyds Register, subject to the notation "Experimental" and "Electrically Welded" being inserted in the Register against the name of the vessel. Few owners care to have this notation, and will not therefore permit the welding of important connections, except perhaps in the case of repairs when time delayed may mean a lot in a charter.

The capabilities of the Operator is the first and most important factor, he must be intelligent, have received a thorough training, be able to differentiate between a structural and non-structural item, understand the type of electrode to use, how to apply it and the amount of current required ; the preparation of the metal to receive weld and the correct finish of weld. Most of these particulars should either be issued in the form of a Standard sheet of Instructions, or else be stated on the plan of each job in the same manner as the present riveting tables. When welding becomes a definite and recognised part of Ship Construction, the Classification Societies will, for uniformity and strength considerations, have to tabulate these particulars in their Rules and Regulations.

To advance welding, Builders should decide on certain items that could, without offence to Owners, be welded. By repeating the welding of these items in each vessel built at their Works, many of which are sure to be for the same Owners, experience and confidence is given to the Operator, and opportunities provided for the Owners Superientendent to occasionally inspect the connections, and to observe how they resist corrosion, by sea water and their behaviour under service conditions. Should these periodic surveys satisfy the Superintendent, it will probably be found that the welding clause, in the specifications of new vessels, has become more elastic.

The following items are a few which can readily be welded and are being generally adopted as "accepted items" by most of the up-to-date Shipyards. Those stated under (A) are minor and non-structural, but those under (B) should not be attempted unless the Owners consent has been obtained, and must also be approved by the Classification Society under whose survey the vessel is being built.

(A)

Rail Stanchions to deck.
Rail rod butts.
Vertical flange of ventilator rings.
Galley and Accommodation Fittings.
Ventilator coaming butts.
Cowl rests on ventilator coaming
Butts of Bulwark Rail.
Small Skylights.
Small Tanks.
Engine Skylight.
Laddersteps and Gratings.
Door frames, hinges, etc., to deck-houses.
Insulation lugs to bulkheads.
Screen bulkheads.
Coal shoots.
Butts of bulkhead boundary bars.
Butts of tank division boundary bars.
Partition bulkheads.
Gutterbars to base of O.T. Bhds.
Cargo batten cleats.
Small isolated deckhouses not covering openings through deck.
Tank top ceiling lugs.
Manhole rim angles or coamings.
Collars at frames of W.T. flats.
Eyeplates, etc., for cargo handling gear.
Pipe clips.
Electric light fittings.
Cover plates on shipside discharges.

(B)

Tank Intercostals to Floor plates clear of machinery space and under pillars.
Tank division and floor stiffeners.
Tunnel stiffeners to tank top plating.
Edges of doubling plates at pillar feet.
Continuous frame bracket gusset plate to W.T. bulkheads.
Corners of W.T. bulkhead boundary angles.
Peak bulkhead bottom plate to shell plating.
Bulkhead plating to tunnel sides.
Plate shoes in lieu of tie back bar at decks.
Sole plate to end of solid hold or tween deck pillars.
Waterway bars to deck.
Bulwark stays to deck and bulwark.
Bilge keel to shell plating.
Butts of bilge keel plate.
Hatch webs.
Flat iron between frames for hold sparring.
Winch pipe seating and girders.
Stringer bar butts.
Cargo door stiffeners.
Deck girder butts.
Girder tripping brackets.
Derrick seams and butts.
Crane post seams and butts.
Chain pipe to deck plating.
Steam bar butts.
Breast hooks to shell plating.

It may appear that some of the foregoing items could not be economically welded, and this would undoubtedly be the case, if the design of the job is not modified from rivetting to welding requirements. Shipyards who have adopted some of these items, will have the work properly designed in the Drawing Office to suit welding, and not allow the Yard to weld angle bars to deck, etc. when a weld "vertical flat" is sufficient for the purpose intended. It is good practice to test the work of the Operator from time to time by welding butts of bars, etc., and subjecting same to hydraulic hammer test. This should also be done for the benefit of an Owner or Inspector who has doubts regarding the efficiency of welded connections. It is also useful for record purposes, the yield point, ultimate strength, and nature of failure, all being recorded.

A few of our well known Naval Architects have designs prepared for the all-welded ship, and it is regretable to note that these designs have not been used for vessels of higher class than the Barge. Our Continental and American Competitors are, however, more progressive, and have actually constructed small oil Tankers having welded connections, etc., with the result of a considerable saving in steel weight, and increased carrying capacity. In view of this, and owing to the present precarious condition of the Industry, we should endeavour to overcome the prejudice to welding. and do everything we can to improve and further its claims to beat the Foreign Competitor and establish ourselves not only as the Premier Builder of Riveted Ships, but also of Welded Ships.

NOTICE TO CONTRIBUTORS

The Publishers welcome articles and correspondence of interest for "The Welder." Articles should be typewritten if possible, and an enclosed addressed envelope should accompany all contributions. Photographs of interesting welding jobs will be especially welcome. All correspondence appertaining to the Magazine should be addressed to the Editor of "The Welder," Ferry Lane Works, Forest Road, London, E.17.

Institution of Welding Engineers Prize Competition, 1930

ON Thursday, 12th February, 1931, the name of the winner of the Operatives' Prize Competition, 1930, organised by the Institution of Welding Engineers was declared at a meeting of the Society held at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1.

The winner, who is Mr. E. Storey, of Billingham, was awarded the Gold Medal and also the Prize, and a Certificate, and Silver Medals were handed to those whose papers were highly commended.

Mr. Storey then read his paper entitled "Welding Practices and Methods based on my own Experiences," which was illustrated by Lantern Slides and was followed by a discussion.

A few words relating to the winner of what is the first competition of its kind to be held in this country, should not be out of place.

Mr. Storey was trained some years ago in Messrs. Swan, Hunter, Wigham Richardson, Ltd. Welding School under the direction of Dr. J. H. Paterson, D.Sc. who is now a Joint Managing Director of Messrs. Murex Welding Processes Ltd. Since then he has been employed by a number of firms who are large utilisers of welding processes, including Messrs. A. Reyrolle & Co. Ltd., and the South Durham Steel and Iron Co. Ltd., and is at present employed by Messrs. Synthetic Ammonia and Nitrates Ltd. During the War, Mr. Storey served with the Royal Army Service Corps, 1914 to 1918. The paper discusses a number of jobs done in the Works of the last mentioned Company, which were mostly carried out with Premier and A.W.P. Electrodes, and will be issued shortly in volume form with the other papers which were highly commended.

British Industries Fair, Birmingham

THE British Industries Fair, Heavy Industries Section, was held at Castle Bromwich, Birmingham, from February 16th—27th inclusive, and as announced in our February issue, Murex Welding Processes Limited were represented by a stand which was 50% larger than the one occupied last year by the Premier Electric Welding Co., Ltd.

At the moment of writing it is too early to gauge to what extent the Fair was successful from the business point of view. It must, however, be admitted that great interest was aroused in some of the new machines which were on view such as the Atomic Hydrogen Plant, the Automatic Welding Plant, and the Diesel Engine Set for two Operators.

Great interest was also shown in the demonstrations which were given daily in the welding of copper by the Premag Process, and the enquiries in connection with the welding of stainless steel and special alloys were numerous.

Credit should be given for transporting the larger machines and for erecting these on the Stand, including the starting up of the Automatic Plant, to Messrs P. A. Lewin and Hammond, who after working throughout the week-end, only succeeded in completing this on the Sunday night previous to the opening of the Exhibition.

The number of visitors, including old friends and customers, were perhaps larger than expected, although foreign buyers were few and far between. Great credit is due for the success and smooth running of the Company's stand, not only to the above-mentioned, but to the various Sales Representatives who were on duty on the Stand each week, and also to the Demonstrators who at busy periods each day were greatly taxed.

The idea of featuring "The Welder" Kiosk has undoubtedly justified itself, and a number of valuable new readers, contributors, and entrants to our Monthly Competition have been added to our list.

In one case a Works' Manager of a large Boiler Manufacturing Company in the Midlands insisted that all his welders should enrol themselves as readers. In this case there were 29 welders.

It was also perhaps surprising to find that a considerable number of visitors to "The Welder" Kiosk were already in receipt of "The Welder" each month, and the unsolicited tributes paid to this publication were very numerous.

Within the next few months the practical results of the British Industries Fair, Birmingham, should be felt. Space has already been booked for the 1932 Fair.

Section of Stand 15C showing Automatic Welding Plant and Atomic Hydrogen Process.

Another section of Stand showing 2 Operator Diesel Engine Set.

The Welder Kiosk.